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Submarine Debris Flow Impact on Pipelines: Mass Movement Dynamics, Drag Forces, Mitigation and Control

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Submarine mass wasting processes as landslides and debris flows are amongst the most destructive geohazards, both economically and environmentally, for installations on the seafloor. Estimating the drag forces on pipelines caused by these geohazards is an important design consideration in offshore engineering. The methods available are limited in terms of the application and the prediction of drag forces is very uncertain. There is significant room for improvement and new research to advance the state-of-the-art. To this end, an experimental program consisting of laboratory flume experiments integrated with Computational Fluid Dynamics (CFD) numerical analyses was performed to investigate the impact on two pipeline installation scenarios: 1) suspended pipeline and 2) laid-on-seafloor pipeline. The results and observations from the experimental investigation are presented. The definition of Reynolds number was modified for non-Newtonian fluids and an ad hoc method was developed to estimate the drag force exerted by an impact perpendicular to the pipe axis. The method may be used in prototype situations to estimate the drag force from submarine debris flow impact on pipelines. Impact mitigative and control measures can only be assessed once the drag forces are accurately estimated. We investigated the effect of two conceptual mitigative and control measures for design against submarine debris flow impact: 1) the berm-protected laid-on-seafloor pipeline and 2) the cable-controlled pipeline system. The observations from a laboratory flume experiment with a model pipe protected

by an upstream berm and complementary Computational Fluid Dynamics (CFD) numerical analyses results are presented. The results from the flume experiment illustrate that there is a possibility to protect a pipeline provided the protective structure can withstand the basal shear forces induced by the debris flow on its surface. The analysis methodology may be tailored to other situations and used for detailed design. The feasibility of the two conceptual mitigative and control measures is briefly discussed.